The Roentgen Rays

Their Production by Static Generators and Methods of Application

THE ROENTGEN RAYS

THEIR

PRODUCTION

AND

USE

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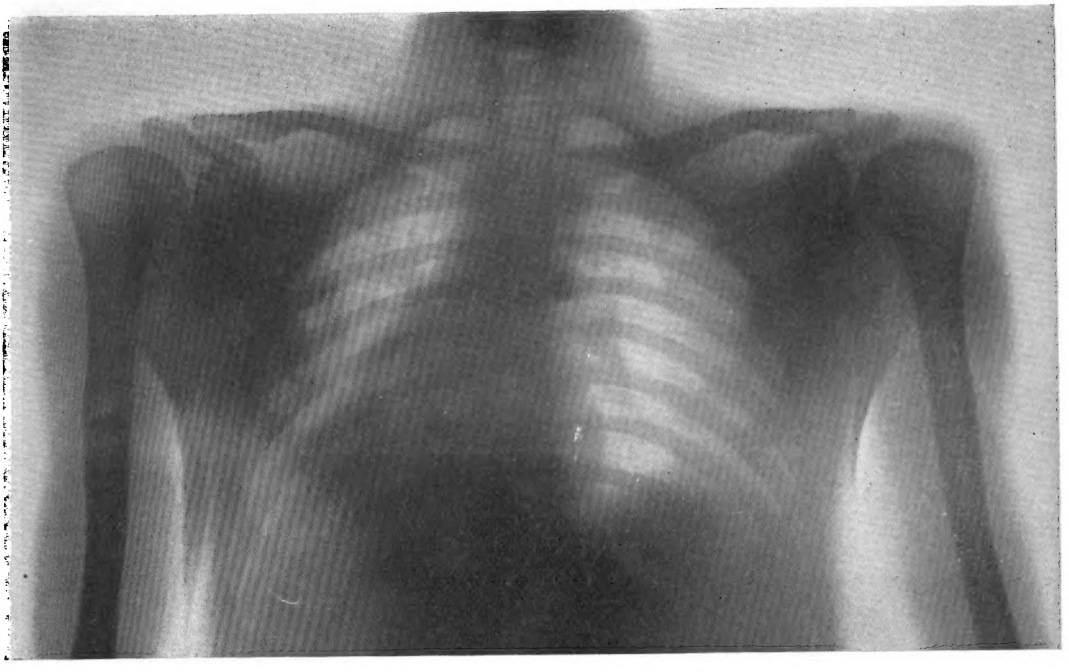
INTRODUCTION.

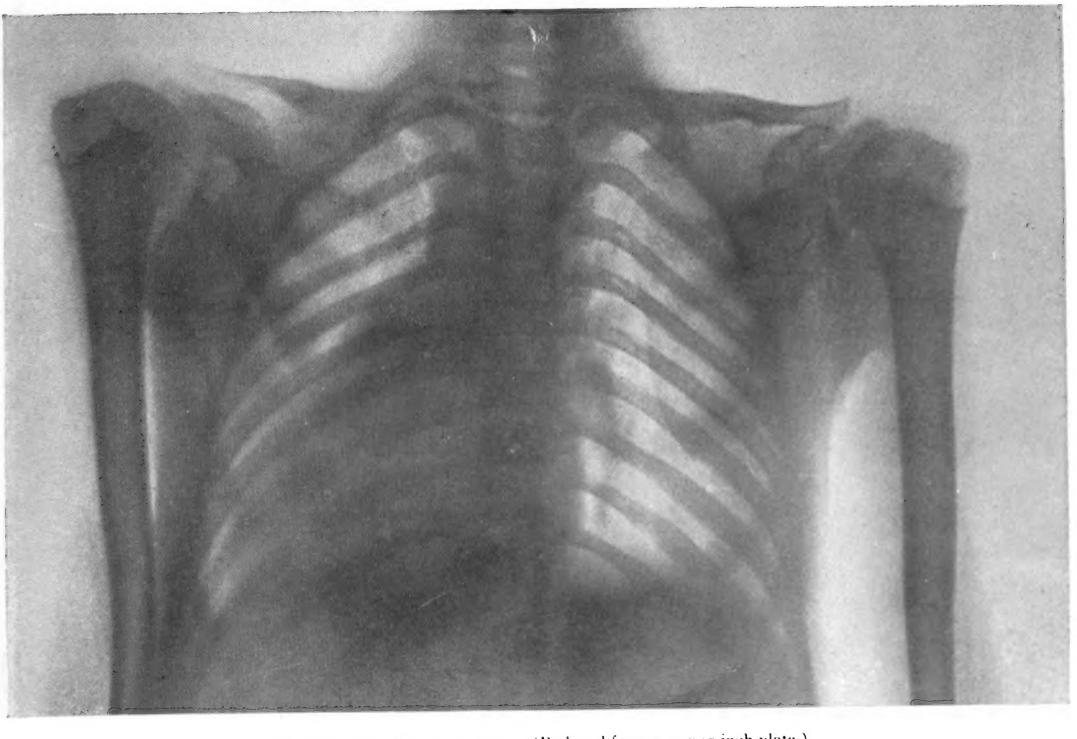
This pamphlet is addressed to any person who may be interested in the subject of the Roentgen rays and the approved methods of producing and making use of them. It presents the claims of a form of static machine which has had a successful trial of more than a year, and which stands to-day, all things considered, as the most practical high voltage generator yet produced, suited not only for use with Crookes tubes but also for all purposes for which static machines are employed. It describes also the latest improvements in all x-ray accessories, and gives some suggestions upon the methods of applying the x-rays to examinations for surgical and medical purposes.

The plates are illustrations of work done by the "Standard" New Holtz Machine as used in the laboratory of the Cambridge Manual Training School, covering a wide range of cases about three hundred in number. In no case has the time of exposure been hastened, as is often done, by fluoroscopic sheets placed upon the photographic plates. All are examples of genuine x-ray photography. For such parts as the hand and arms the time of exposure has been from one to three minutes; for the knees, three to ten minutes; for the trunk, ten to thirty minutes. Fluorescent screens, in certain exposures, will reduce this time almost to as many seconds.



THORAX OF AN ADULT.

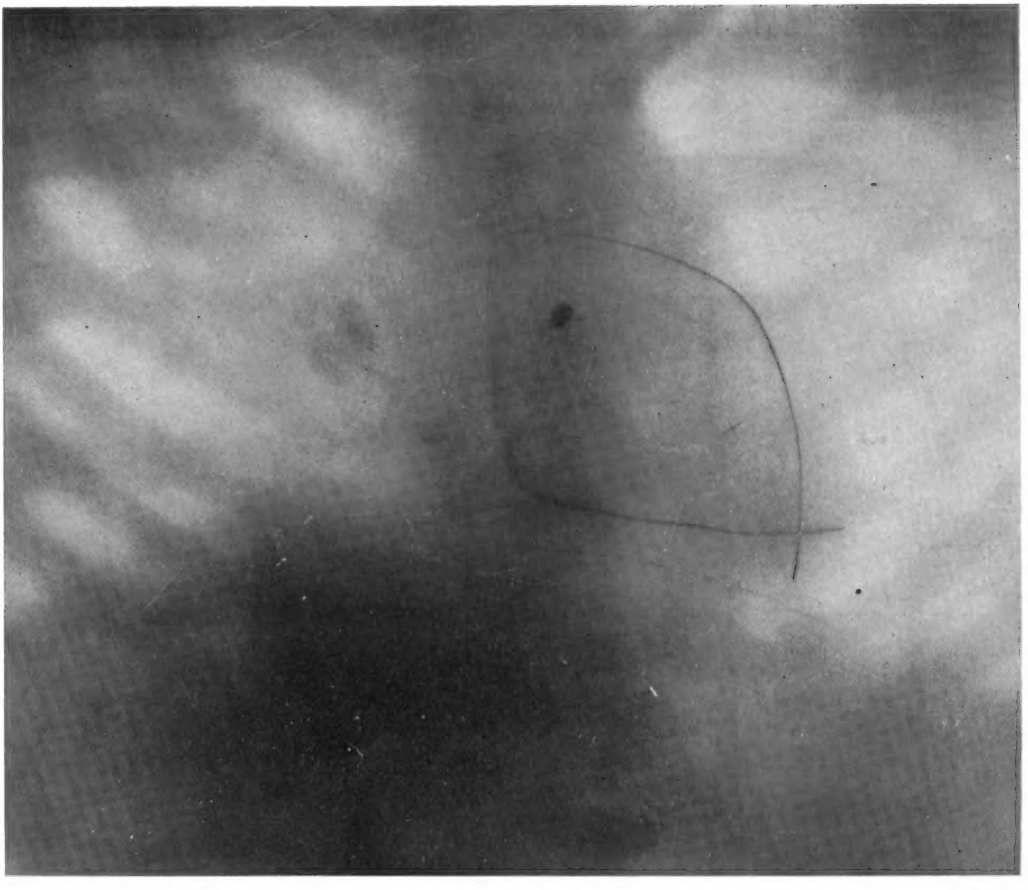
Copy of an x-ray skiagraph made June 14, 1897, on a 20 x 24 inch plate using the "Standard" New Holtz Machine. An equally satisfactory skiagraph of the pelvis of the same subject has been made.



THORAX OF A BOY, 13 YEARS. (Reduced from a 14 x 17 inch plate.)

Copy of an x-ray skiagraph of a youth's back and shoulders, made July 24, 1896, in the laboratory of the Cambridge Manual Training School, the Crookes tube being excited by the New Holtz Machine at a distance of 2 feet from the plate. The heart and other opaque vital organs were badly defined on the photographic plate on account of motion; but they appeared distinctly upon the fluoroscopic screen.

PLATE I.



BULLET NEAR THE HEART.

This is a case of unusual interest. The bullet, fired from a 32 calibre revolver at close range, entered the anterior chest-wall near the apex of the heart, at the point marked with a cross, was deflected by the rib and lodged against the posterior aspect of the gladiolus, slightly to the right of the median line. The wire outlines the position of the heart and area of cardiac dullness. The bullet could not be traced by probing and was located by the "Standard" New Holtz Machine, notwithstanding its position required the penetration by the x-rays of three comparatively opaque substances, viz.: the vertebræ, the heart and the breast bone. The ill defined shadows of the ribs are due to the movements of the patient and the nature of the exposure. This case, with others, is fully described in Annals of Gynæcology and Pædiatry, February and April, 1896. It was from the Cambridge City Hospital, Drs. Taylor and Henshaw.

PLATE II.

THE ROENTGEN RAYS

And the Conditions Necessary to Produce Them.

I. Probable Nature of the Roentgen Rays.

Real nature not known.

Very little is positively known about the nature of the x-rays of Roentgen. Experimenters have learned much about the properties of this wonderful agency, its uses, the conditions necessary for its production and the various methods of application; but the real nature of the transformation which takes place within the Crookes tube, while it is sending forth the x-rays, is still as much a matter of hypothesis as it was when Roentgen first announced his now famous discovery. A full discussion of the subject would be foreign to the purposes of this pamphlet; but a passing reference to one or two points in the dominant theory may not be out of place.

Are probably very short ether waves.

From the first, scientists have generally agreed that the Roentgen rays are probably due to a wave motion in the ether, in kind not essentially unlike light waves, which Hertz and others have proved to be electrical. They are known to differ from ordinary light waves principally in being much shorter and of much higher frequency than any waves hitherto observed. According to the measurements of Fomm, the Roentgen rays, although they undoubtedly vary considerably in length, have in general about one-fifteenth the wave length of ultra-violet light. Before the publication of these results Dr. Oliver Lodge expressed the belief that the x-ray wave length, when determined, would be found to be much shorter than the shortest waves of the spectrum and, indeed, comparable with atomic dimensions. The observed parallel between the relative transparency to x-rays of certain substances and their atomic weights rather than their specific gravities is perhaps worthy of note in this connection. Roentgen's original suggestion that the direction of vibration in the new rays may be along the line of wave propagation instead of being at right angles to it, in other words longitudinal instead of transverse, as it is in ordinary light waves, remains still open to question. No observations have been reported either as opposing this hypothesis or as a sufficient foundation for it.

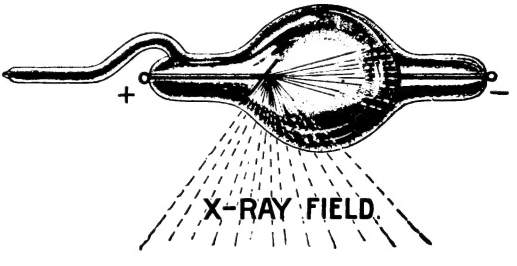
II. Crookes Tubes.

Apparatus required for modern skiagraphy.

Turning to the practical side of this subject we find that two pieces of apparatus are essential for the production of Roentgen rays, — first, a properly constructed Crookes tube, and second a suitable source of electricity in the form of the disruptive discharge. Some of the special requirements which must be met by apparatus designed to secure the best results in skiagraphy according to modern standards will next be explained.

Source of the Roentgen radiation.

The real nature of the action which goes on in a Crookes tube when producing x-rays, as has already been stated, is unknown, but it may be positively asserted that some small area within the tube, which receives that mysterious force emanating from the negative terminal or cathode, becomes the source of the Roentgen radiation. In modern tubes this source is a very small portion of the surface of a piece of platinum foil attached to the positive terminal or anode of the tube, or suspended in front of the anode without electrical connection. With regard to the peculiar action of the cathode just referred to, it may be well to say that about twenty years ago Crookes



Cathode rays.

discovered that when an electrical discharge is passed through the so-called high-vacuum tubes, a form of energy is developed at the cathode terminal which seems to throw out a stream of some sort from the surface of the cathode in lines perpendicular to it. The direction of these cathode rays was observed to remain normal to the surface of the terminal from which they were thrown out, whatever angle that surface might present to the line of direction of the current through the tube. It was therefore possible, by changing this angle, to throw the rays in any direction and, by using a concave disc for the cathode, to focus them upon any point. They were shown to cause mechanical motion, heat and fluorescence, and to be deflected by magnets.

In order to produce the cathode rays, which are a necessary condition for the generation of the Roentgen rays, it is essential, as is well known, that a very high degree of exhaustion be obtained in the vacuum tube. Ordinary vacua, such as serve for incandescent lamps, will not do because they are too low; and, on the other hand, the exhaustion must not be carried to the highest degree practically attainable, for, in that case, the resistance of the tube will become so high that sufficient current cannot be forced through it to produce the desired effect. An exhaustion to about one-millionth of an atmosphere is generally conceded to be the proper condition so far as it is possible to express it in figures. But in reality it is a matter of careful experimental adjustment, rather than of exact measurement. Experience in the use of vacuum tubes for x-ray generation has shown that slight variations in the tenuity of the residual gas, even after the required exhaustion has been reached, alter the character of the rays and thus modify the results obtained by their use. Indeed, this point is of the greatest practical importance in skiagraphy. In pumping tubes it is observed that, when the vacuum is at the lowest state at which it is possible to produce x-rays at all, the flesh of the hand and fingers casts a dark shadow upon the fluoroscopic screen, the bones being entirely invisible. As the pumping proceeds, the flesh gradually loses its opacity and the bones appear,—at first dimly and with ill-defined outlines, then more clearly until, finally, they become distinct and well defined in the faint shadow of the flesh around them. For a tube intended only for use with the hand and thinner parts of the body we should stop here and, if possible, maintain the exhaustion at exactly this degree. But a higher penetrating power is desirable for examinations of such thicker parts of the body as the knees, shoulders and trunk. This is accomplished by producing a slightly higher degree of exhaustion. Such a tube as is suited to this latter purpose, however, would give a weaker skiagraph of the hand, because the rays thrown off by it would penetrate the thinner bones of the hand almost as readily as the flesh. A tube may be exhausted to such an extent that, when driven with a powerful coil, it will render the bones of the hand only faintly visible on the fluoroscopic screen or the photographic plate. Such a tube, even if a generator of sufficient power to force a current through it is accessible, is nearly or quite useless for Roentgen ray photography. Desirable tubes are those properly constructed and exhausted to a degree suited to the character of the work they are expected to do.

A nicely adjusted vacuum necessary.

Variation in the penetrating power.

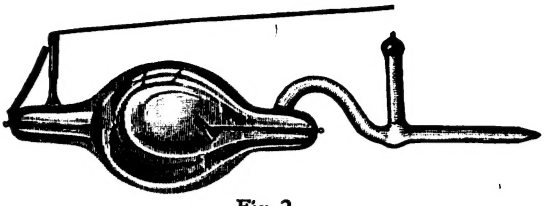
Since the introduction of the so-called focus tube, the first great improvement, designers have been busily employed in devising ways to secure a proper condition of vacuum, durable and capable of easy adjustment; for it was universally recognized that along this line the next great step in advance was to be taken. The importance of this matter lay not only in the desirability of having a tube properly adjusted to the work demanded of it, but also in economical considerations. In use, especially with coils, tubes run up so high, even in a single examination sometimes, as to become useless. Such a result has been ascribed to the occlusion of some of the residual gas by the walls of the tube and by the terminals against which the gaseous particles have been driven by the discharge within the tube. It may be corrected in a measure, generally, by heating the tube reasonably hot over a Bunsen or alcohol flame. But this is not a thoroughly

How the nature of the vacuum may be controlled.

By heating.

satisfactory method. The use of large tubes, which must contain a considerable store of residual air to start with, has been an improvement, as also have been smaller tubes with attached reservoirs. But these all run up sooner or later and require re-exhaustion. Another method of controlling the vacuum is that employed in the Bowdoin College tube. In addition to other unique features this tube has a fluorescent substance deposited upon its interior, which is designed to reinforce the vacuum when it becomes too high. The latest device, and one which seems to be very successful, is the so-called self-regulating tube. The operation of the regulating device depends upon the increase in the resistance of the vacuum as it runs up in use. There are several forms, the simplest of which is illustrated in Fig. 2. The end of the movable arm is set at any required distance from the small bulb which opens into the tube near the anode terminal. This bulb contains a substance from which a vapor is readily thrown off when a spark is passed through it. Now when the vacuum of the tube has increased, so as to make its resistance higher than the resistance of the air between the end of the movable arm and the terminal of the bulb, the current takes the path of lesser resistance and sends a succession of sparks across the gap. This causes a vapor to be thrown off from the substance in the bulb and thus furnishes the needed reinforcement to the residual gas in the tube. The resistance of the tube being thus brought back to its normal condition, the current returns to its original path through the tube, restoring it to its proper function. The spark-gap of this tube can be easily varied in length. By this means the vacuum is not only self-regulating but adjustable, within certain limits,

By using large tubes and reservoir tubes.



By an interior coating.

Fig. 2.

Self regulating tube.

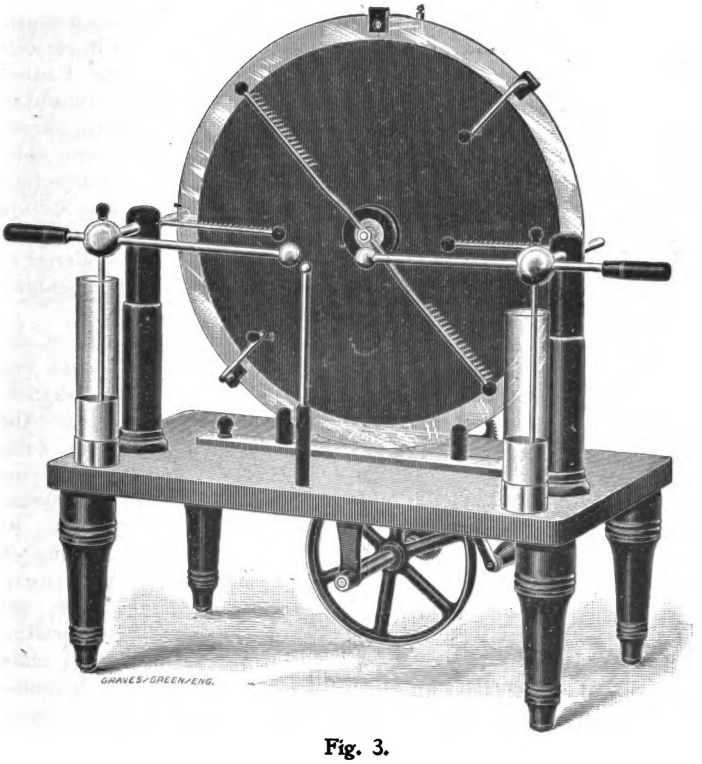


Fig. 3.

Adjustable spark-gap.

ONE OF OUR MANY TESTIMONIALS.

THE WAVERLY TRAINING SCHOOL,
WAVERLY, TENN., July 6, 1897.

Mr. Charles F. Warner,

DEAR SIR:—I desire to write you and tell you of the wonderful success I achieved with the tube you sent me. I have used it for three heavy exhibitions, and it is apparently as good as ever. It gave the most beautiful results, throwing out a strong light, which enable one to see through the chest, an international dictionary, and to discern the shadow of a piece of metal through the head. This last was quite plain. I have had one fifteen dollar tube, and have seen others, but this was superior to any of them.

Yours truly,

W. E. MILLER.

III. STATIC GENERATORS AND ROENTGEN RAY PRODUCTION.

Success of the New Holtz Machines.

The first successful static machines designed especially for Roentgen ray production were put upon the market in October, 1896, by Mr. F. O. Stanley of the Stanley Dry Plate Co., Newton, Mass., and by Mr. Charles F. Warner of the Cambridge Manual Training School. Brief as the time of trial has been, they have demonstrated their high efficiency for use with Crookes tubes, as well as for all other purposes for which static generators are employed, through the varying climatic changes of an entire year in various sections of the United States; and, on account of their convenience, safety and inexpensiveness, they have placed themselves in the front rank among the several types of electrical machines offered to purchasers of Roentgen ray outfits.

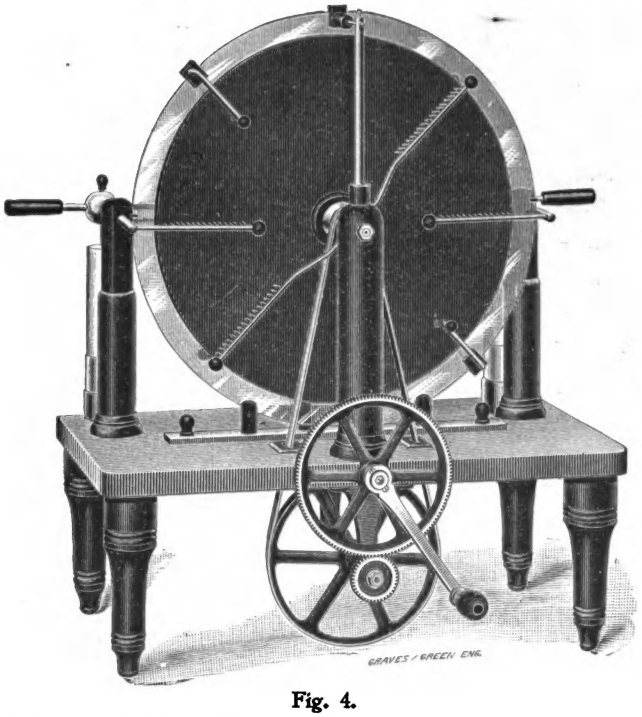


Fig. 4.

Why static discharge is superior to all others.

The superiority of the discharge from static machines for the peculiar requirements of the Crookes tube in x-ray generation was suspected from the first on account of its high tension, its freedom from heating effects and consequent economy of tubes, the simplicity of its production, its oscillatory character, and the suddenness of its interruptions. These admitted properties of static discharges, together with the successful experience of the past year, justify us, we believe, in recommending the New Holtz Machines in the highest terms. In this belief we are also supported by the opinions of many disinterested experts. We will mention a single authoritative statement which appeared in the *Medical Record* (New York) for June 26, 1897, page 903, in an article by S. H. Monell, M.D. The statement is as follows:—

An elbow examined for fracture and none found.

Copy of a skiagraph of a pelvis; reduced from a 14x17 inch plate.

PLATE III.

1. Apparent Greenstick fracture.

2. Another view of the same.

(Illustrating the necessity of two views in x-ray examinations).

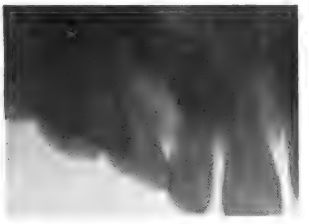
3. Fractured tibia: limb in plaster cast.

4. Supernumerary bone in foot.

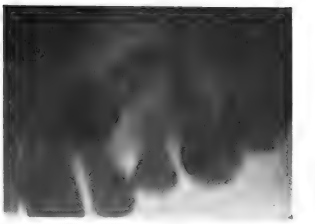
A Group of Surgical Cases.

(Illustrating important uses of x-ray examinations).

PLATE IV.

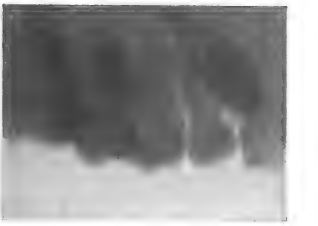


1

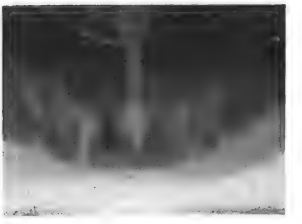


2

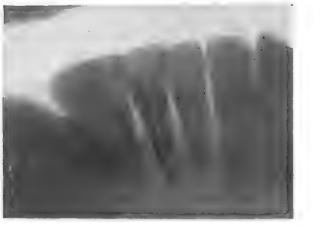
Imbedded cuspids with retained temporary cuspids; girl, 21 years.
No. 1. Right side. No. 2. Left side.



Imbedded cuspid with retained temporary cuspid; patient 23 years of age



Permanent teeth pushing out temporary teeth; boy, 8 years.



Fracture at tip of the root of inferior central, caused by a blow from a polo mallet.

Fillings, some extending into the root.

1

2

Drill in jaw tissue. No. 1 shows it emerging apparently from pulp cavity; No. 2, taken at a different angle, shows it to be between the roots of central and lateral. It was successfully removed after having been in the jaw more than a year, causing severe abscess.

COPIES OF DENTAL SKIAGRAPHS.

These interesting exposures were made principally by Dr. Dwight M. Clapp, of Boston, using the "Standard" New Holtz generator. They illustrate an important application of Roentgen radiography in dental diagnoses.

PLATE V.

(1) A fractured ulna.
(2) A hand: skiagraphed in one minute.
(3) Left foot, naked.
(4) Right foot of same person, in a pointed shoe.

PLATE VI.

"*The Holtz Machine with tubes adapted to its maximum discharge will readily and economically equal or surpass the best x-ray effects producible by any or all other means of electrical excitation with any design of tubes that can now be obtained.*"

IV. Specific Features of the New Holtz Machines.

In order to explain definitely the claims on which we base our recommendation of this type of electrical generator for the production of x-rays, we will describe their special features in detail. Most of the forms of static machines existing when the problem of the New Holtz was undertaken were unable to produce discharges of sufficient power and frequency to maintain an x-ray tube in action; and those that were able to do the work were too cumbersome and too expensive to be practical. The mechanical design of these older machines was such that powerful discharges could only be obtained by using a large number of plates, on account of the slow rate of motion attainable. To overcome this defect Mr. Stanley conceived the idea of so designing a machine that it would be practicable to employ a *high rate of speed in the revolving plates and thus make one or two do the work generally done by five to ten times that number.* This was successfully accomplished by using two rubber revolving discs, 17 in. in diameter, mounted on ball bearings and driven by a set of gears so that a speed of 2,000 to 2,500 revolutions per minute could be easily obtained. The accompanying figures will illustrate the simple mechanism employed to produce the desired speed.

High speed the essential feature.

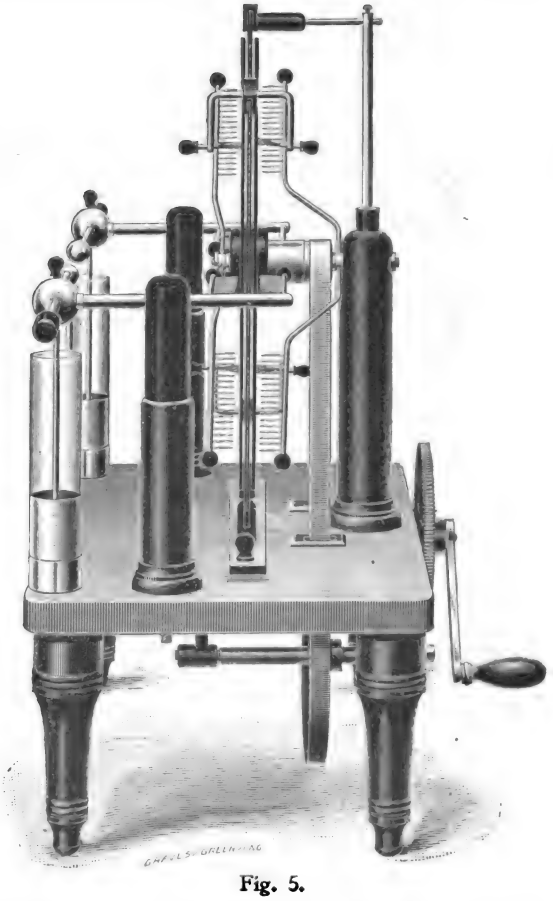


Fig. 5.

Other unique features of this design, which were developed by careful experimenting, may be summed up briefly as follows:

Other specific features.

1. The use of specially vulcanized rubber in the discs, which prevents warping; and a special preparation of the surfaces.
2. Two armature plates of the highest specific inductive capacity, coated with a varnish of uncommonly great insulating power.
3. A case to protect the essential parts from dust and moisture.
4. Light running parts and a belt that cannot slip.
5. General mechanical firmness and durability combined with light weight.

6. Easy adaptability to various forms of motive power though designed to be run by hand.

7. Low first cost and small cost of maintenance.

Three elements of special value have been established by a year's experience with the New Holtz machines:—

Efficiency.

1. They give a torrent of oscillatory discharges of great volume and constant potential, easily held at the maximum, and capable of exciting Crookes tubes powerfully and producing results never inferior and often superior, in depth and definition, to those given by the various methods employing the dynamic current.

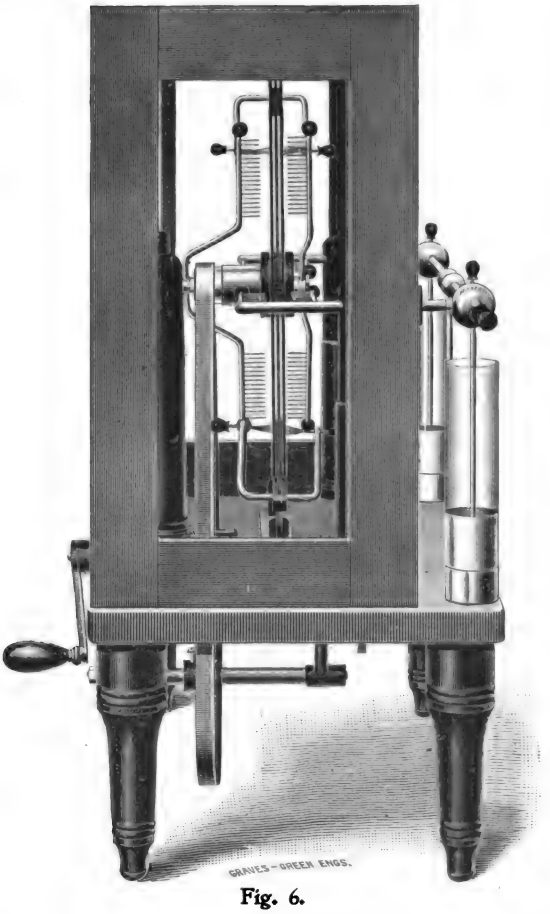


Fig. 6.

Economy.

2. The discharge from these machines does not heat the tubes appreciably; it does not require in tubes so high an exhaustion to begin with as is needed for coils, and it does not affect the condition of vacuum so readily as the current from Ruhmkorff and high frequency coils; it never burns out the terminals; it is not so liable to puncture tubes by external discharges.

Safety.

3. It does not generate a great excess of current which cannot be utilized in the Crookes tube. It is a feature of static machines in general that they give an oscillatory discharge of very high potential and an almost immeasurably small current, which is precisely the condition generally admitted to be required to produce the Roentgen ray effect. It is this quality of discharge that the various forms of coils strive to imitate but are never able to attain, excepting in the case of the high frequency or Tesla coils, which, however, greatly overdo the matter and have been generally abandoned in connection with x-ray production. *The malignant burns and other deleterious effects* which have been reported in connection with x-ray examinations and which should be attributed to the excess of electrical discharge and not to the x-rays themselves properly applied, *have resulted when coils have been used and not with static generators*, excepting possibly certain cases of excessive and unnecessary exposure. With these machines not only are the patient and operator protected from the so-called x-ray burns, but the terminals and conductors may be handled, if necessary, when the machine is charged without serious inconvenience. This is an advantage of no small moment.

Static machines do not burn the patient nor operator.

The New Holtz Machines, varying somewhat from the original design in some cases,

are now offered for sale by several dealers in various parts of the United States. **The American Roentgen Ray Company** will furnish them, either directly or through its authorized agents, in *three sizes or styles*, made according to the *original designs* just described, with the latest minor improvements, and *guarantee them to be genuine in every respect.*

Headquarters for the genuine New Holtz Machines.

Style A.—The Standard. This has two rubber revolving discs. It was with this style of machine that the work illustrated in this circular was done. The "Standard" is recommended as the most generally useful of the three styles.

Style B. This has four rubber revolving discs. It is designed for therapeutical purposes; but it may be used for the excitation of Crookes tubes especially when unusually powerful x-ray effects are sought. It is believed to be equivalent to a twenty-four plate Toepler Holtz Machine of the form employing glass revolving discs.

Style C. This has a single rubber revolving disc and one glass armature plate. In all other respects it is the same as Style A. It is capable of producing good x-ray effects, but it requires longer exposures. It is recommended as entirely satisfactory for illustrative purposes; and it is undoubtedly the most efficient single plate static machine ever put upon the market.

V. Fluoroscopes.

Fluorescent substances.

The substance which fluoresces most brilliantly and with the best definition under the action of the Roentgen rays, so far as chemists have been able to determine, is barium platino-cyanide, freshly prepared and properly applied to the screen surface. This was the substance used for fluoroscopic tests by Roentgen in his investigations, and it has been employed by all his followers to a greater or less extent. Not only does this substance give the most brilliant fluorescence, but it is practically non-phosphorescent; *i. e.*, when once excited it does not continue to emit light, even faintly, after the Roentgen rays have ceased to fall upon it. This quality of non-phosphorescence, it will be readily seen, is of great importance in cases where nice distinctions in detail or opacity are to be made out; for, if phosphorescence is likely to be present, it will be impossible to distinguish a faint shadow from an area which, though actually out of reach of the x-rays, may be faintly shining on account of previous excitation. For this reason surgeons need a non-phosphorescent fluoroscope.

Barium platino-cyanide.

Importance of non-phosphorescence.

Calcium tungstate.

No known substance, as has been implied, exceeds barium platino-cyanide, properly prepared, either in brilliancy or in the quality of non-phosphorescence; but there are certain difficulties in the way of its exclusive use for fluoroscopic screens. Its expensiveness and its tendency to easy decomposition, in common with all cyanides, are the principal drawbacks. Although both these objections have been largely overcome by the untiring labors of experimenters during the past year, so that a durable fluoroscopic screen of the platinum salt may now be obtained at a reasonable cost, there is still a demand for a less expensive screen, even at slight loss in brilliancy. Calcium tungstate is the only substance yet found to meet this requirement. The ordinary preparation of this salt gives a very brilliant fluorescence, and on account of its low cost is much used in making screens for exhibition purposes. But for the use of surgeons a non-phosphorescent preparation, first made by T. B. Kinraide of Jamaica Plain, has given excellent satisfaction. For a standard outfit we would recommend a small fluoroscope with barium platino-cyanide screen and a large fluoroscope having a screen coated with the non-phosphorescent preparation of calcium tungstate. It is well to have the large screen detachable so that it can be easily removed for exhibition purposes.

Non-phosphorescent substances.

Our recommendation.

Mounting.

Fixed visual distance.

The proper mounting of fluoroscopic screens is a matter not always given due consideration. The ordinary pyramidal box (see cut, outside cover) with a leather shield for the eyes is perhaps all that is needed for general use; but with such a mounting the

Adjustable visual distance.

visual distance is absolutely fixed. For a careful and accurate examination of delicate gradations or slight movements in shadow, with a screen capable of bringing out these finer details, it is essential to have a visual distance adjustable to the peculiar requirements for keen vision in the individual observer. The open box, with the head shielded by a black cloth, meets this need to a certain degree. But a more convenient arrangement is illustrated in Fig. 7. The screen is attached to a camera bellows which may be easily opened or closed. The shield for the eyes is held in position by a stout elastic band slipped over the head. This allows an easy movement of the head towards the screen or away from it, in order that the best visual distance in each case may be found. When folded up, the instrument makes a parcel about one inch thick and may therefore be carried about conveniently.

Fig. 7.

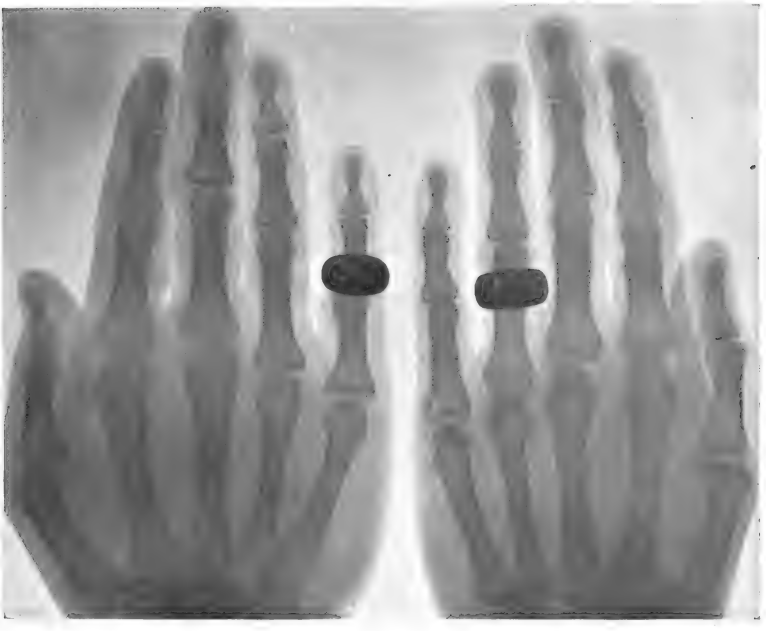
The diaphragm screen.

Another important accessory to the proper fluoroscopic outfit is some arrangement for cutting off the x-rays from all portions of the screen excepting the one area, small it may be, where a particular detail is to be examined. Many observers have failed to see the finer shadows that are really present on account of the general glare of the screen. This is easily remedied by employing a diaphragm of sheet brass so constructed that it may be placed in front of the fluoroscopic screen, with its opening, which may be varied in size, over the part where the examination is to be made.

VI. Roentgen Ray Photography.

The requirements for Roentgen ray photography are of the simplest sort. Probably any kind of a photographic plate or film will serve the purpose. Bromide paper has been successfully employed with the advantage of giving a positive when developed. Both films and sensitized paper admit of easy duplication, since a large number, an entire package for example, may be exposed at the same time without removing them from their paper covers. In using plates it is necessary to make individual exposures on account of the opacity of glass to x-rays. For this purpose plates are put up in individual wrappers with the film sides marked, so that it is not necessary to use plate holders. Many, however, prefer the latter, as they protect the plates from breaking. The relative positions of the tube, plate and object to be skiagraphed are illustrated in plate VIII, which shows a simple method of making a skiagraph of the hand. The plate holder having been loaded with a single plate, film side outward, as for ordinary photography, the hand is placed directly on the slide, which protects the film from the light but not from the x-rays. The rays from the Crookes tube fall upon the sensitive film affecting it in the same manner as light, excepting where they are cut off or absorbed, partially or wholly, by some object more or less opaque to them, in which case the integrity of the silver salt is, to a greater or less extent, preserved. After a sufficient exposure the plate is developed and fixed as in ordinary photography. The result is a shadow picture or skiagraph of

Character of the picture.



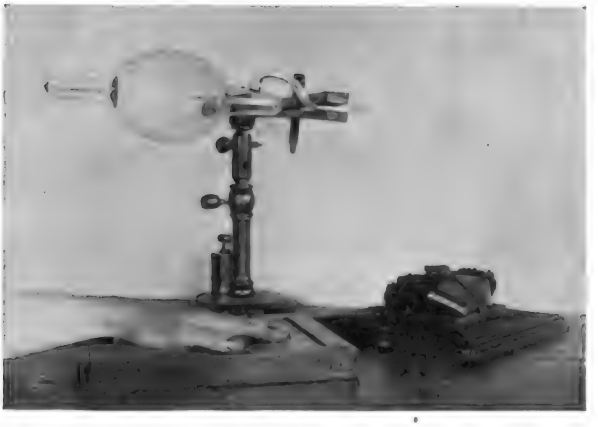
Skiagraph of two hands: illustrating clear definition.

Needle and coin under a hand. Note eye and point of the needle as an evidence of clear definition.

Skiagraph of a hand made in *two seconds*. A fluorescent screen was used on the right side. Note the increased contrast between bone and flesh

COPIES OF SKIAGRAPHS ILLUSTRATING DEFINITION.

PLATE VII.



The relative position of tube, plate and object.
Fluoroscope folded up.

The method of using the fluoroscope.

PLATE VIII.

the opaque parts of the object laid on the slide. The picture is slightly larger than the object because the rays concerned in producing it radiate from a portion of the anode of the tube much smaller than the object or parts of the object casting the shadow. By bringing the object nearer the picture may be made still larger, and, if too near, it will be distorted. The proper distance of the tube from the plate will depend upon the size and shape of the object to be skiagraphed. For the hand or teeth, six to ten inches is a good distance; for the knee or foot, ten to fourteen inches; for the various parts of the trunk, fifteen to thirty inches. It is well not to bring the tube so near to the flesh, especially the sensitive parts, that the electrical discharges from the tube may be felt. Neglect of this caution has caused the burns attributed (not by experts) to the Roentgen rays. It is particularly necessary to keep the tube at a proper distance when using a coil.

Distance of tube from plate.

Time of exposure.

The time required to make a fully exposed x-ray negative depends upon so many varying conditions that it is impossible to lay down definite rules. It depends, in general, upon the intensity of the rays as they fall upon the plate; and the intensity is variously modified. The following general principles embody some of the conditions which must be kept in mind:—

General principles.

1. The intensity of the x-rays, since they radiate from a small area or point on the anode, varies inversely as the square of the distance. If an exposure of one minute will suffice with the plate six inches from the anode, an exposure of four minutes will be required when the plate is one foot away, other things equal.

Distance.

2. The intensity of the x-rays is variously reduced by the thickness of materials through which they must pass to reach the photographic plate. This is evidently due to absorption which varies with different substances. Experience must be the guide in this matter. Not only the bones but the thicker parts of the flesh and the vital organs greatly diminish the power of the rays to affect the film. In making skiagraphs of these parts the plate is in no danger of over-exposure.

Absorption.

3. The intensity of the x-rays varies with the kind of generator used to excite the vacuum tube, with the changes in the condition of the same generator, with the condition of the atmosphere, whatever the kind of generator used, and with the changes in the condition of vacuum. Here, again, experience is the only safe guide. One fact, however, is well established, namely, that a comparatively low vacuum tube, of the best x-ray type, affects a photographic plate more powerfully than those of higher exhaustion. The latter are necessary for great penetration, but they lose in intensity as measured by the photographic test. The margin of a plate exposed for a hand one minute with a low tube will often develop as dense as the freely exposed part of a plate kept under a higher tube a much longer time and at the same distance in making a skiagraph of a knee. *This is a suggestive fact to those who wish to compare static machines with coils for x-ray work, inasmuch as it is well known that coils require higher vacua than the statical generators.*

Tubes lose in photographic power as they run higher.

Tubes pumped for static machines have greater photographic power.

4. For the New Holtz Machines a general rule may be derived from the following table:—

For	the	hand	from	1	minute to	3	minutes.
"	"	arm	"	2	" "	6	"
"	"	ankle	"	2	" "	10	"
"	"	knee	"	5	" "	15	"
"	"	thorax	"	10	" "	30	"
"	"	pelvis	"	15	" "	40	"
"	"	thigh	"	15	" "	40	"
"	"	shoulder	"	15	" "	40	"

5. The foregoing table is based upon experiments in which no device has been employed to hasten the photographic effect. But if a properly constructed fluorescent

How the time of exposure may be greatly lessened.

screen be laid over the photographic film and the exposure made as before, the time may be reduced, generally speaking, from minutes to seconds. There is a slight loss in definition resulting from the use of this method; but, notwithstanding this, it is an invaluable aid in many cases.

Development of x-ray plates.

The illustrations in this pamphlet are from x-ray photographs made upon Stanley dry plates, No. 50 (sensitometer). Experience has taught us that harsh development is preferable. For this purpose nothing excels the ordinary pyro-developer, particularly with the Stanley dry plates. A little longer time, generally, is required than for light exposed plates. Some observers have suggested that the maximum x-ray effect is to be found on the side of the film next the glass. This may account for the longer time required for development.

Only ordinary care required.

No greater care need be exercised with x-ray plates than is essential for ordinarily good work in amateur photography. Dealers in photographic materials will willingly furnish needed information on this point.

A FEW SURGICAL CASES IN WHICH THE NEW HOLTZ MACHINE WAS USED.

Nos. 37, 38 and 39. Fractured tibia and ankle, for Dr. Allen, of Arlington.

Nos. 42 and 44. Examination of knees for tuberculous condition, for Dr. C. F. Nichols, of Boston.

Nos. 52 and 53. Lame knee, for Dr. C. F. Nichols, of Boston.

Nos. 56, 57, etc. Fractured tibia of foot ball player, for Dr. F. W. Taylor, of Cambridge. Several sets of skiagraphs of this case were made at intervals of a week while the leg was in plaster cast. (See Plate IV).

No. 60. Injured thumb, for Dr. H. O. Marcy, of Boston and Cambridge.

No. 62. Pelvis of child, for Dr. W. J. Winn, of Cambridge.

Nos. 66 and 67. Needle imbedded in partella of a child, for Dr. Carr, of East Cambridge.

No. 68. Needle in a finger, for Dr. Cunningham, of East Cambridge.

Nos. 69 and 70. Pelvis — hip disease of long standing — for Dr. Driver, of Cambridge.

No. 77. Injured finger for Dr. G. B. Henshaw, of Cambridge.

Nos. 89 and 90. Compound fracture of humerus and femur, for Dr. G. B. Henshaw, of Cambridge.

No. 95. Sprained elbow joint, for Dr. J. T. Nichols, of Cambridge. (See Plate III).

No. 98. Needle in hand, for Dr. MacKechnie, of Somerville.

No. 120. Base ball finger, for Dr. Geo. P. Cogswell, of Cambridge.

No. 125. Fracture of metatarsal for Dr. Eugene A. Darling, Cambridge.

No. 130. Child supposed to have swallowed a McKinley button.

No. 158. Fractured tibia and fibula, for Dr. H. O. Marcy, Boston and Cambridge.

No. 161. Tuberculous knee, for Dr. Tuttle, of Cambridge.

Nos. 179 to 184. Six plates of leg of motorman injured in Boston Subway explosion, March 4, 1897, for Dr. H. B. McIntire.

Nos. 192 to 195. Dental examinations for Dr. Geo. R. Taft, Cambridge, Mass.

No. 203. Bullet in breastbone. Case of Smith, for Dr. F. W. Taylor, of Cambridge. (See Plate II).

No. 205. Bullet in groin, case of U. S. Blake, of Dorchester, for Dr. Geo. B. Henshaw, of Cambridge.

No. 225. Case of periostitis, for Dr. H. O. Marcy, Boston.

SOME OF THE PURCHASERS OF THE NEW HOLTZ.

The following list of Educational Institutions, Hospitals, Physicians, and other parties, selected from those that have been supplied, will show the character of the purchasers and range of our sales.

Educational Institutions.

Acadia College, Wolfville, N. S.; Adelphi College, Brooklyn, N. Y.; Atlanta University, Atlanta, Ga.; Bowdoin College, Brunswick, Me.; Brown University, Providence, R. I.; Cambridge Manual Training School, Cambridge, Mass.; Colby University, Waterville, Me.; Cook Academy, Montour Falls, N. Y.; Cushing Academy, Ashburnham, Mass.; Dedham High School, Dedham, Mass.; Elmira College, Elmira, N. Y.; East Side High School, Milwaukee, Wis.; Farmington Normal School, Farmington, Me.; Fitchburg Normal School, Fitchburg, Mass.; Haverford College, Haverford, Pa.; Manual Training High School, Brooklyn, N. Y.; Massachusetts Institute of Technology, Boston, Mass.; Mechanic Arts High School, Boston, Mass.; Miami University, Oxford, Ohio; North Carolina Medical College, Davidson, N. C.; Phillips Academy, Andover, Mass.; St. Benedict's College, Newark, N. J.; University of Michigan, Grand Rapids, Mich.; University of Oregon, Eugene, Or.; University of North Carolina, Chapel Hill, N. C.; University of Tennessee, Knoxville, Tenn.; Washington and Lee University, Lexington, Va.; Western Reserve University, Cleveland, Ohio; Williston Seminary, Easthampton, Mass.; Worcester Polytechnic Institute, Worcester, Mass.; Worcester English High School, Worcester, Mass.

Hospitals.

Arnott Hospital, Elmira, N. Y.; Emergency Hospital, Boston, Mass.; Newton City Hospital, Newton, Mass.; St. Luke's Hospital, Utica, N. Y.; Waltham Hospital, Waltham, Mass.

Physicians and Surgeons.

Dr. H. R. Ainsworth, Addison, N. Y.; Dr. A. B. Briggs, Ashaway, R. I.; Dr. D. M. Clapp, Boston, Mass.; Dr. Thos. Conant, Gloucester, Mass.; Dr. N. R. Hall, Warren, R. I.; Dr. Geo. B. Henshaw, Cambridge, Mass.; Dr. C. W. Hoyt, Corning, N. Y.; Dr. W. E. Hibbard, Providence, R. I.; Dr. M. A. Hudson, LaFayette, Ala.; Dr. C. P. Jones, Southboro, Mass.; Dr. Geo. H. Matchett, McPherson, Kan.; Dr. J. H. Mudgett, E. Barrington, N. H.; Dr. John H. Neal, Rochester, N. H.; Dr. A. G. Nye, Weymouth, Mass.; Dr. Mark S. Purdy, Corning, N. Y.; Dr. F. T. Rogers, Providence, R. I.; Dr. Frank W. Ross, Elmira, N. Y.; Dr. C. L. Squire, Elmira, N. Y.; Dr. Roswell Wetherbee, Cambridge, Mass.; Dr. O. B. Will, Peoria, Ill.

Other Parties.

R. N. Davis, Archibald, Pa.; Henry Greene Co., Hartford, Conn.; C. A. B. Halverson, Saugus, Mass.; Ernest H. Lewis, St. Albans, Vt.; C. A. Page, Methuen, Mass.; F. W. Traphagen, Bozeman, Mont.

There are many others and the list is constantly growing.

NET PRICES.

Style A, (The "Standard") $45.00; or $50.00 with Crookes tube
Style B, . . Price on application.
Style C, . . $30.00; or $35.00 " " "
Crookes Tubes, $5.00 and upwards according to style and size
Fluoroscopes, $5.00 " " " " "
Ruhmkorff Coils at reasonable cost.

A full line of Accessories at lowest prices. For details, consult the Price List of the American Roentgen Ray Company.

TESTIMONIALS.

From an Eminent Surgeon of Boston:

180 Commonwealth Ave., Boston, Sept. 22, 1897.

Dear Mr. Warner: — Let me thank you for excellent service. I take pleasure in commending your work. Sincerely, HENRY O. MARCY.

From Professor Trowbridge, of Harvard University, referring to work done by the New Holtz Machine.

I am very much obliged for the superb photographs you kindly sent me. They are the best I have seen and I shall greatly enjoy showing them to my friends.

From Professor H. C. Bumpus, of Brown University:

I consider your Static Machine the most satisfactory instrument for the production of x-rays now on the market.

From Prof. Chas. R. Cross, of Massachusetts Institute of Technology:

I have made frequent use of the machine, and find it very efficient and thoroughly reliable.

From Prof. C. C. Hutchins, Bowdoin College, Brunswick, Me.:

The machine works all right; has never reversed or refused to start.

From Prof. D. R. Ford, of Elmira College, Elmira, N. Y.

At a recent meeting of the Elmira Academy of Sciences, we had three of your machines in operation, with great success, before an audience of 1,000 people.

From Prof. Frank P. Whitman, of Western Reserve University:

The Holtz Machine and fittings have been received, set up and tried. There is no doubt about the excellence of the results, which are fully comparable with what I have been able to obtain from a 12-inch coil. . . It may be of interest to say that I have obtained with your machine excellent fluoroscopic effects through the adult human body, showing the beating of the heart, the movement of the diaphragm, etc. . . You have certainly produced an excellent machine and one which is mechanically so much better than the ordinary ones, that I should think it would commend itself to schools, not only for x-ray work, but all other work for which a static machine is useful.

From Dr. F. T. Rogers, Providence, R. I.:

I have used the new x-ray machine for some months and find it very satisfactory. I do not believe there is anything better made.

From G. B. Henshaw, M.D., Cambridge, Mass.

I desire to express to you my thorough satisfaction and delight with the work done by your Holtz machine. As an aid to the diagnosis and treatment of recent or old fractures, dislocations, deformities, and new growths, from a surgical standpoint, and a revelation of the condition of the lungs, heart, liver, abdomen and pelvis from a medical point of view, the work you have already done with the machine has proved that the x-ray is indispensable to the busy practitioner in his daily work.

From Dr. Frank W. Ross, Elmira, N. Y.

The apparatus — New Holtz — arrived to-day in good order. I have set it up, and it works beautifully. Had a 7 1-2 inch spark to-night, and think I might have gotten an eight. . . . I can only repeat my former statements in praise of the apparatus.

From Dr. H. R. Ainsworth, Addison, N. Y.

Let me say that I congratulate myself upon having so complete an outfit, working as it does, charmingly.